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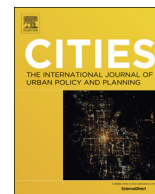
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Traffic pollution: A search for solutions for a city like Nairobi

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ABSTRACT

Congestion and traffic-related pollution are typically the largest contributors to air pollution in cities. Rapid urbanization in developing countries has caused large-scale proliferation in motor vehicle use making cities increasingly congested and, subsequently, polluted. There is a growing awareness that the air quality status quo in East African cities is unacceptable. This paper uses the case of Nairobi, Kenya to discuss current traffic pollution challenges and how they may be addressed. The paper begins with an overview of urbanization and pollution effects. It goes on to look at the specific case of Nairobi as it searches for solutions to the negative impacts of pollution through a lens which sees resolution of congestion effects as key to amelioration of traffic-related air pollution. It suggests that a combination of infrastructure, policy, regulatory and softer measures may provide the most effective way to address traffic congestion and, thus, traffic pollution. In addition, the paper highlights the need for further research into the lived experience of negotiating daily life in Nairobi, as well as further exploration of the social, economic and environmental feasibility of potential solutions for the city. While Nairobi is used as the case study city, the lessons learned are generalized for cities in the East African region, which often share similar traits of congestion and traffic related pollution.

1. Introduction

Cities have been central to human development (Riffat, Powell, & Aydin, 2016) and to advanced civilization's concept of cultural and economic accomplishment (Droegge, 2008). Over the past two centuries, the movement of people to live in cities and large towns has meant that the proportion of the world's population living in urban areas has grown from around 5% to 50% (McMichael, 2000). By 2050, this proportion is estimated to rise to around 66%, with most of the growth being in developing countries (UN, 2014). Urbanization has been associated with increasing pressure on cities worldwide. In Africa, Ingwe et al. (2008:631) suggest that “the high rate of urbanization...has not resulted in improved living standards (better paying jobs, infrastructure and services, clean and modern electricity, potable water and so forth). Increasing urbanization of the developing world has created a large mass of urban poor”.

In emerging and developing economies, the rapid convergence of people on cities supplies human resources which contribute to potential economic growth but also intensifies the strain on already vulnerable resources such as land, water, housing and other infrastructure such as transport. The impacts of motorized transport in cities can be seen in congestion, accidents, community severance and pollution. Transport is the greatest contributor to urban air pollution with highest levels of

exposure and pollution at roadside locations (Hitchcock, Conlan, Kay, Brannigan, & Newman, 2014).

This paper concentrates on the impacts of traffic-related pollution on people in developing country cities, with a focus on Nairobi, and the ways in which such effects may be viably addressed to improve the sustainability of urban areas for residents and visitors, the environment and the economy. The paper is largely based on a desk review which is informed by personal experience. It begins with a discussion of traffic pollution in developing countries and cities and goes on to look at the case of Nairobi, Kenya in East Africa. In Section 3, potential mitigating measures for lessening the impact of traffic pollution in cities such as Nairobi are explored. Section 4 discusses the need for more holistic approaches to planning in cities in order to ameliorate pollution effects. Future research which the review suggests may deepen understanding of ways to reduce and ameliorate traffic pollution effects in a developing country context is discussed. The conclusion is in the final section.

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2. Background

2.1. The problem

“(A)s cities grow and become richer, ownership and use of motorized vehicles - including private vehicles (as in Eastern Europe), small buses (as in much of Latin America and Africa) and 2-3 wheelers (as in Asia) - grows more rapidly than the available road space. This results in increased congestion and traffic-generated air pollution... As the sources of pollution differ so would the prescribed solutions.”

(Gwilliam, 2013:4)

Gwilliam asserts above that urban economic growth tends to be characterized by increased motorization. While there are commercial drivers of growing dependence on motor vehicles, (for example, to enable supply of goods to/export of products from cities), with more disposable income and poor public transport options, cultural effects can mean individuals aspire to meet their personal mobility needs through car ownership. However, this can create increased social divisions and inequity as people on low incomes who are already excluded tend to be further marginalized in “peripheral locations or sometimes in inhospitable inner-city locations, with very poor access by the only modes of transport available to them, walking, non-motorized or public transport” (Gwilliam, 2003:201). In the planning of transportation in cities such as Nairobi, Klopp (2012:5) highlights the need for the poorer majority to be included in participatory processes to end “current power dynamics and dominant urban paradigms that favor automobility, which in turn reinforces spatial and social segregation”.

In many developed and developing countries, the unsustainability of continued dependence on fossil fuel based transport has been recognized and there have been several infrastructure, policy and alternative interventions tested to lessen the impacts of environmental pollution associated with mobility, while maintaining and/or improving accessibility. Some examples of such interventions are increased provision of walking and cycling infrastructure in Groningen, banning of city centre access by licence plate in Mexico City (Hoy No Circula, No Driving Today) and congestion charging in London. More recently, in 2017, Santiago, Chile, won the Sustainable Transport Award from the Institute for Transportation & Development Policy (ITDP) for major improvements in pedestrian space, cycling and public transit provision. The city redesigned several central streets to limit car traffic and improve pedestrian, cyclist and transit access. In conferring the award, the ITDP recognized the high quality and transformative scale of these projects and the fact that they were backed by policy changes, education programmes and a huge increase in cycling mode share (ITDP, 2017).

In the absence of pollution mitigation measures and other ameliorative interventions, an urban cycle of rapid economic and population growth continues and, with it, come the negative impacts of increasing motorization, such as rising exposure to road traffic risk in the form of accidents and air pollution, severance, fuel waste and congestion. Looking briefly at the latter, congestion can result in productivity barriers. For example, in São Paulo, traffic jams were estimated to have cost \$17.8 billion in 2012 – the equivalent of almost 1% of Brazil's GDP (Davido, 2014).

Given the congestion link to undermining economic competitiveness, the United Nations summary of some of the key contributors to social and environmental unsustainability found in cities below is also important:

“In many cities in developed and developing countries alike, congestion, pollution, shifting economic centres and demographic patterns present imminent threats to lives and livelihoods. The transport landscape in urban agglomerations is often highly inequitable, with poor and disabled people left with inadequate means to access the economic and social centres of the cities. The burden of climate

change adds another layer of urgency and complexity to the problems decision makers must address in their quest to create sustainable cities.”

(UN, 2016)

The United Nations Environment Programme (UNEP) predicts that half the world's population growth in the next 30 years will be in Africa and that, left unchecked, this will be associated with a dramatic rise in the number of cars and volume of emissions in African cities:

“The vehicle fleet will double in the next seven years in Nairobi,” says Rob de Jong, Unep's (sic) head of transport. “The number of cars in Africa is still relatively small, but the emissions per vehicle are much higher [than the rest of the world].”

(Vidal, 2016)

The need to offset transport effects in urban areas is clearly recognized. Urban air in Africa is said to be poor “...because so few cars are new, the vast majority having been shipped in second hand from Japan and Europe with their catalytic converters and air filters dismantled. It is in danger of becoming a dumping ground for the world's old cars – importing vehicles that no longer meet rich countries' pollution standards” (Vidal, 2016). Urban fossil fuel dominated areas need to be replaced by socially diverse environments where economic and social activities overlap and citizens' wellbeing is increased (Riffat et al., 2016). In its recommendations to the UN Secretary General, the High-Level Advisory Group to advance sustainable transport highlights the need for transport planning, policy and investment decisions to be based on the three sustainable development dimensions [social development, environmental (including climate) impacts and economic growth] and a full life cycle analysis (UN, 2016).

2.2. The case of Nairobi

Nairobi has an estimated population of 3.915 million and an area of 696 sq km (UNdata, 2015). The city is unusual in that, alongside its urban core, it has a national park in the central area where endangered black rhino and other wildlife can be found. Due to this wildlife attraction and other more distant attractions, Nairobi is a major tourist gateway for safaris and other forms of holiday. Kenya's capital is one of the largest cities in East Africa and is the region's financial, diplomatic and communication capital (UNCTAD, 2016). A recent Oxford Business Group report indicates that Kenya has been making considerable progress towards strengthening its position as the leading regional transport and logistics centre. However, it also suggests that, while transport investment is recognized to be essential, there is a “hefty infrastructure deficit” (Oxford Business Group, 2016). The Kenya Roads Board provides further insight into the seemingly dichotomous relationship between demands on the transport system and investment in infrastructure to enable sustainable growth. It states that “the transport sector in Kenya combines international quality operators and services, a somewhat run down infrastructure and some inefficient and ineffective institutions” (<http://krb.go.ke/our-downloads/NCTIP/Annexes/Annex%203.1%20Kenyan%20Transport%20Sector%20Details%20ver%201.pdf> p.1 accessed 170317) and goes on to note that the high rate of urbanization in the country has not been matched by “commensurate urban infrastructure and services, most notably in urban transport (p.5)”. The Board also suggests that sustainability may not have been considered as important as economic factors to urban development: “Sustainable environmental policies have not been adequately incorporated in Kenyan road transport infrastructure management policies resulting in pollution and environmental degradation. Factors such as soil erosion, management of gravel pits and road run-off, noise pollution and gaseous emissions by road motor vehicles have not been adequately addressed” (<http://krb.go.ke/our-downloads/NCTIP/Annexes/Annex%203.1%20Kenyan%20Transport%20Sector%20Details%20ver%201.pdf> p.12 accessed 170317). There appears to

be a gap between contemporary transport planning in Nairobi and the UN's Sustainable Development Goals (SDGs). In particular, SDG11 which states “make cities inclusive, safe, resilient and sustainable” and SDG9 – “build resilient infrastructure, promote sustainable industrialization and foster innovation” (<https://sustainabledevelopment.un.org/sdgs>). In addition, clearer focus on SDG13, climate action (Take urgent action to combat climate change and its impacts), is required, given that a reduction of pollutants is often linked to a reduction of CO₂.

The World Bank (Lall, Henderson, & Venables, 2017) suggests that Nairobi's traffic congestion, caused by deficient transportation infrastructure, is crippling the economy. The city is also reported to have one of the longest average journey-to-work times in Africa due to:

“Heavy congestion, high rates of walking, informal collective transportation, and the spatial distribution of jobs and residents lead to low employment accessibility in Nairobi and the misallocation of labour.”

(Lall et al., 2017)

Severe traffic congestion, especially during the extended peak hours, contributes to local air pollution and leads to significant economic losses in time and fuel (Government of Kenya, 2012 cited in Murphy & Harris, 2014). Also, the combination of deteriorating air quality and increasingly bad traffic will likely make Nairobi less attractive as a tourist gateway, therefore, further putting a brake on the economy. Opiyo and Mitullah (2016) outline the transportation challenges in Nairobi that the Kenyan government is seeking to address as:

- Inadequate transport management institutions
- Incomplete transport network and poor inter-modal connectivity
- High cost of land and energy
- Unsafe and insecure transport services
- Congested transport network and environmental pollution.

The number of registered vehicles in Kenya and the rate of change between 2008 and 2012 (most recent data available) helps provide a greater understanding of the traffic volumes/demand on the country's roads. This data is shown in Table 1.

The total number of registered vehicles grew by 77% between 2008 and 2012. The largest contributors to this increase were motor- and auto-cycles with a growth of 368% in 2012 on the levels in 2008. Other motor vehicles (such as road construction vehicles and farm tractors) at 70% higher levels than in 2008, buses and minibuses at 51% and motor cars (43%) were the next highest sources of registered vehicle growth. The only category to have shown a decline in registrations is trailers (–18%).

Table 1

Registered vehicles in Kenya.

Source: Kenya National Bureau of Statistics (http://www.knbs.or.ke/index.php?option=com_phocadownload&view=category&id=91&Itemid=1163 accessed 160317)

Vehicle type	2008	2009	2010	2011	2012
Motor cars	450,137	499,679	553,397	591,958	644,805
Utilities, panel vans, pick ups etc.	209,628	219,901	226,876	234,427	242,372
Lorries, trucks, heavy vans	81,285	91,431	96,355	100,180	108,001
Buses & mini-buses	61,886	84,844	89,708	91,627	93,343
Motor & auto cycles	130,307	252,960	371,747	514,241	610,056
Trailers	43,485	27,039	29,418	32,002	35,763
Other motor vehicles	32,710	45,229	50,038	52,310	55,449
Total	1,009,438	1,221,083	1,417,539	1,616,745	1,789,789

Given this increasing supply of vehicles and the attendant escalation of demand, the emergence of the use of social media to provide unofficial advice on ways to avoid traffic delays has been seen. For example, in Nairobi, the daily experience of traffic congestion has prompted residents to offer online suggestions of ways to avoid the extensive queues (see, for example, <http://omgvoice.com/lifestyle/secret-routes-avoid-traffic-nairobi/>, <https://www.tuko.co.ke/37747-5-worst-traffic-jams-nairobi-avoid.html>), including re-routing and not travelling at all.

Turning to the rapid increase in motor/auto-cycle registrations, government policy may be seen to have made a significant contribution to this growth. However, it is not transport policy that appears to have been the contributing factor. In October 2016, TechSci Research, a research based management consulting firm, reported that the Kenyan government had offered tax waivers for both importation and local assembly of motorcycles. It reported further that the removal of taxes was aimed at improving sales and reducing job losses. The rapid take up of local assembly is illustrated in the opening of 21 assembly plants since 2011 (when there were none) (<https://qz.com/800070/the-value-of-motorcycle-public-transport-will-more-than-double-in-africa/> accessed 220317). It is likely that many of these vehicles are meeting the demand from the boda boda (motorcycle taxi) market where they offer the advantage of being able to move quickly, if dangerously (in terms of accident causation and air pollution), through queueing traffic, while also facilitating mobility when car ownership is unaffordable and urban public transport options are limited or undesirable.

Nevertheless, some steps are being taken towards lessening the impacts of traffic in Nairobi. It is understood that a transport and urban decongestion committee was set up in early 2014 (<http://www.nairobi.go.ke/home/news/transport-and-urban-decongestion-committee-launched/>). It released an interim report in June 2014 and has a Facebook page listing press releases with associated photographs (<https://www.facebook.com/nrbcitycountytraffic/>). In addition, the Nairobi City Governor announced in 2015 that 20% per cent of all funds allocated to roads' budget would be committed to construction of non-motorized transport (NMT) and public transport infrastructure (<http://www.fiafoundation.org/blog/2015/april/nairobi-to-invest-in-walking-and-cycling>). It was reported that this “policy will act as a catalyst in creating a safe, cohesive and comfortable network of footpaths, cycling lanes and tracks, green areas, and other support amenities. It will also spearhead the introduction of laws and regulations to ensure that NMT facilities and areas are prioritised” (<http://www.fiafoundation.org/blog/2015/april/nairobi-to-invest-in-walking-and-cycling>). The potential benefits of this political commitment could provide significant air pollution benefits. The World Bank reports that, in 2011, total CO₂ emissions in Kenya were 13,568 million metric tonnes (<http://data.worldbank.org/country/kenya>), with 39% of this figure from the transport sector (5,291,520 metric tonnes). The University of Cape town recently piloted a NMT cost benefit analysis tool in Nairobi which “... demonstrated that a move to a city-wide network of NMT infrastructure in Nairobi could potentially result in a reduction of over 2 million metric tonnes of CO₂ emissions in a fifteen-year period. A host of other benefits were also identified including the potential for over 400 years of travel time to be saved and over 8000 premature deaths to be prevented” <http://www.ppmc-transport.org/share-the-road-prioritizing-walking-and-cycling-in-nairobi/>.

It is reported that Nairobi is a city “...where 47% of the population walk as their main daily mode of transport. Research by the Japanese International Cooperation Agency (JICA) found in 2004 that, out of 4.82 million person trips per day 2.32 million...were made by walking and bicycles.” (<http://www.fiafoundation.org/blog/2015/april/nairobi-to-invest-in-walking-and-cycling>). Another source suggests that “50% of the population either walk or cycle to their destination every day” (Henry Ochieng, Chief Executive Officer @ <https://nairobiplanninginnovations.com/2016/02/29/investment-in-non-motorized-transport-key-to-addressing-transportation-challenges-in>

kenya/.) If these figures are correct, it appears that, although very few people actually cycle (c.3% mode share) at present - which may reflect the absence of dedicated infrastructure, regulation or policy for cycling - there is great potential within the allocation of a proportion of the roads' budget to NMT infrastructure and, specifically, interventions for cyclists.

In terms of walking, with around half of the travellers in Nairobi already making walking trips despite a lack of dedicated infrastructure, there is a firm basis upon which increased levels of walking may be encouraged through well-maintained pavements, green walking routes, optimized pedestrian phases at intersections and other facilitators of easy walking trips. The following vignette provides an insight into the reasons that a focus on walking is needed in Nairobi:

“Non-motorized transport (NMT)-walking and cycling-have been completely neglected in Kenya's capital. This is evident to anyone walking around the city on the many poor sidewalks with crater-like potholes. Incomplete connectivity forces you dangerously onto the street with cars and matatus [minibuses] and of course, the lack of proper markings, traffic management and crosswalks makes crossing many streets a gamble with death. Many pedestrians are killed in the city, and it is hard to imagine what walking in the city feels like for a small child.”

(<https://nairobiplanninginnovations.com/2014/12/12/finally-nairobi-is-developing-a-policy-for-cyclists-and-pedestrians/>)

Writing in the Financial Times, Honan (2016) summarizes the challenges that Kenya faces. She suggests that “high growth figures and rapid urbanisation across east Africa have made the construction of rail lines, seaports and better roads more urgent. But improvements to infrastructure have lagged behind and local officials have estimated that Nairobi loses \$500,000 in productivity every day in snarls of traffic” (Honan, 2016).

In Nairobi, particulate matter (PM) pollution regularly exceeds the daily WHO guidelines for PM_{2.5} and PM₁₀, which are 25 and 50 µg/m³, respectively, e.g. Gaita, Boman, Gatari, Pettersson and Janhäll (2014). Similar results are also seen in the work of Kinney et al. (2011) and Ngo et al. (2015). An overview of PM pollution in African cities is provided in Petkova, Jack, Volavka-Close, and Kinney (2013), which highlights the paucity of such measurements in many urban African locations including those in East Africa. de Souza et al. (2017) highlight that next generation low cost sensors could provide greater spatial mapping of urban air pollution in Africa but further work is required in their calibration. Recent work reporting efforts at calibration are now appearing in the literature, for example Crilley et al. (2018) and Pope, Gatari, Ng'anga'a, Poynter and Blake (2018). PM_{2.5} and PM₁₀ are particulate matter with diameters < 2.5 and 10 µm, respectively. As expected, the greatest PM concentrations are observed at roadside locations where the contribution from vehicles is highest. High quality data for gaseous vehicular pollutants such as nitrogen oxides and sulphur dioxide do not currently exist for Nairobi but it is likely that they will also exceed WHO limits. Poor air quality increases human mortality and morbidity (Lelieveld, Evans, Fnais, Giannadaki, & Pozzer, 2015) thereby hindering the economy by increasing market costs including higher expenditure on health, loss of labour productivity, and the impact of illness on education. Since road traffic, and hence air pollution, varies both temporally and spatially, the health-related outcomes will affect different groupings (gender, age, class, profession, etc.) to varying degrees resulting in potential environmental inequalities, whereby some people are exposed to greater levels of harmful particulate matter than others.

3. Intervention options

3.1. Overview

The need for political, planning and engineering interventions to

lessen traffic impacts and pollution effects of transport in cities worldwide is evident. Pollution mitigation options can be diverse and indirect, achieved through behavioural change, modal shift and infrastructure improvements rather than solely focused on technological advances and adoption of cleaner energy supplies. Schwela and Haq (2013) suggest that the ameliorative effects may be achieved as follows:

“A range of policy options can deliver low-carbon, low-cost transport solutions. They can be categorized within an A-S-I strategy:

- **A = Avoid** travel by reducing the need to travel longer distances.
- **S = Shift** transport demand, when possible, from cars to public transport, walking and cycling, and shift freight from trucks to rail and water.
- **I = Improve** vehicles that use fossil fuels to make them cleaner and more fuel-efficient.

Considerable knowledge exists about transport interventions, initiatives and infrastructure improvements that can contribute to sustainable human development while reducing GHG emissions. While finance will continue to be a challenge, many are lower-cost than, for example, major highway projects as well as bringing co-benefits, including improved quality of life in African cities... Measures such as bus regulation and planning, promoting non-motorized transport, land-use planning and bus rapid transit can help countries avoid the hyper-motorization phase often associated with development.”

For Nairobi, belching exhausts, exposure to pollution in traffic queues, hazardous walking and cycling trips and a socially inequitable hierarchy of road users which favours the car need to be rebalanced to provide an environment where clean air, simple trip-making and access to key facilities, services, workplaces and social activities can be accomplished with ease. Movement towards this future vision may be achieved through both infrastructure investment and other means. Section 3.2 concentrates on the former and the following section explores the latter.

3.2. Current infrastructure changes

There are a number of political statements, denoting steps towards positive action, which suggest that there is a recognition of the need for a refocusing of infrastructure investment in Nairobi away from traditional expansion of the road network. This is important as there is a long-established (since 1925) effect recognized in transport policy and practice called ‘induced traffic’ (Goodwin, 2006), whereby new roads are seen to generate new traffic. Nevertheless, as previously mentioned, Nairobi's governor has stated that 20% of the roads' budget will be ring-fenced for public transport and walking and cycling improvements. For the policy's success, there needs to be accountability for the safeguarding of these finances and robust decision-making frameworks to ensure expenditure is prioritized for areas of work that will offer the greatest wins for current and potential public transport users, pedestrians and cyclists. Users need to be co-designers of schemes to increase the likelihood that any new infrastructure will meet people's requirements, thereby heightening the likely use of new facilities. Complementary safety auditing of the new infrastructure and funds for its maintenance are equally important to the continued success of any mode shift achieved. Evaluation and monitoring of usage levels and changes in traffic pollution levels would also be necessary. For example, such monitoring has revealed some success achieved in routing pan African Heavy Goods Vehicles (HGVs) outside the city, when they are travelling to different cities. That is, by example, the road from the port in Mombasa used to go through Nairobi but now bypasses the city for trucks travelling to destinations further afield such as Uganda.

In addition, there are plans for a major infrastructure project in Nairobi: the introduction of a new bus rapid transit (BRT) system. The Nationally Appropriate Mitigation Action (NAMA) describes the system

as follows:

“The NAMA will use the existing and approved Government of Kenya-World Bank program to upgrade Highway A104 infrastructure as the “window of opportunity” to incorporate a single route for an eBRT. The NAMA will support the development of the first line, the Ndovu (elephant) line, of the BRT system for the Nairobi Metropolitan Region. The NAMA will support the overall implementation of the BRT system, beginning with construction of dedicated bus lanes through to the commissioning of the eBRT stock in 2018.

The main NAMA intervention is the introduction of a “green” electric bus fleet under a private sector framework. The main actions to be supported through the NAMA are:

- Start operation of a private sector-based BRT fleet of electric battery powered buses;
- Establish and operate a NAMA Finance Facility to financially support the eBRT system;
- Integrate affected stakeholders, youth and women into the eBRT value chain;
- Establish policy-driven mechanisms to encourage a safe and secure line and interconnectivity of the “last-mile” for commuters; and
- Support establishment of a NAMA coordinating and implementing entity.

The Nairobi BRT system is expected to have five interconnected lines; and NAMA activities will be replicated for the four other lines - Simba (lion), Chui (leopard), Kifaru (rhino) and Nyati (buffalo) between 2020 and 2030.”

([http://www.starckplus.com/documents/briefing/Bus%20Rapid%20Transit%20\(BRT\)%20Plus%20System%20for%20the%20Nairobi%20Metropolitan%20Region.pdf](http://www.starckplus.com/documents/briefing/Bus%20Rapid%20Transit%20(BRT)%20Plus%20System%20for%20the%20Nairobi%20Metropolitan%20Region.pdf) accessed 260317)

It is projected that the overall annual emissions reduction potential of the entire BRT system may be up to 2 million tonnes of carbon dioxide equivalent by 2030 ([http://www.starckplus.com/documents/briefing/Bus%20Rapid%20Transit%20\(BRT\)%20Plus%20System%20for%20the%20Nairobi%20Metropolitan%20Region.pdf](http://www.starckplus.com/documents/briefing/Bus%20Rapid%20Transit%20(BRT)%20Plus%20System%20for%20the%20Nairobi%20Metropolitan%20Region.pdf) accessed 260317).

3.3. Current policy and regulation

There is evident political interest in resolving some of Nairobi's traffic congestion. This is illustrated in the setting up of a ‘Transport and Urban Decongestion Committee’ which released an interim report in June 2014 (The Global Grid, 20 November 2014). In addition, an awareness of the negative impacts of polluting older vehicles in Kenya is demonstrated in the import restriction on cars which are > 8 years old (<http://www.revenue.go.ke/customs/faqcustoms.html>). By comparison, Nigeria limits imports to 15 years and younger (<http://www.trade.gov/td/otm/assets/auto/TBR2015Final.pdf>), Tanzania's limit is 10 years (<http://www.theeastafrican.co.ke/news/Kenya-to-uphold-age-limit-on-EAC-vehicle-imports/2558-2961008-oe52ve/index.html>) and there are no age restrictions in Uganda (<http://www.theeastafrican.co.ke/news/Kenya-to-uphold-age-limit-on-EAC-vehicle-imports/2558-2961008-oe52ve/index.html>), Botswana, Burundi, Democratic Republic of Congo, Malawi, Mozambique, Zambia or Zimbabwe (<http://www.japancarsdirect.com/regulation.php>).

Importantly, behind these positive indicators, lies Kenya's Vision 2030 long-term development blueprint for the country. The Vision 2030 aim is to realize “a globally competitive and prosperous country with a high quality of life by 2030” by transforming Kenya into “a newly industrializing, middle income country providing a high quality of life to all its citizens in a clean and secure environment” (Opiyo & Mitullah, 2016). In terms of transport, a strategy called Metro 2030 backs up the Vision 2030 goals, seeking to mitigate the challenges of urbanization and focused on developing an efficient transportation

system that minimizes travel times as well as reducing externalities (Opiyo & Mitullah, 2016). The Metro 2030 strategy focuses on the capital city's central role in national development. It recognizes the need to optimize mobility and accessibility in the Nairobi Metropolitan Region and aims at reducing traffic delays and congestion. The Bus Rapid Transport (BRT) is seen as one of the key components of the strategy (Opiyo & Mitullah, 2016).

3.4. What else could be done?

In the short term, there are a number of options which could also make a contribution to decreasing congestion and traffic pollution in Nairobi. Temporary and/or permanent vehicle access restrictions could be adopted in various ways. For example, HGVs and highly-polluting vans could be re-routed away from the city centre during peak hours to help ameliorate some of the traffic congestion and associated pollution. Another option would be to restrict vehicle access by the most polluting vehicles during certain times of the day.

The restriction and bans on particular vehicle types could be formalized further through the introduction of Clean Air Zones as Denmark and Germany have already done. While there has been some debate about the long term success of such schemes in European cities (see, for example, Holman, Harrison, & Querol, 2015) at reducing PM₁₀ and NO₂ concentrations by more than a few per cent, in the UK, there are Clean Air Zones planned for introduction in 2020 in a number of cities where air quality is lowest (Birmingham, Leeds, Nottingham, Derby, Southampton). The UK Department for Environment, Food and Rural Affairs (DEFRA, 2015) indicates that these “(z)ones will not affect private car owners, but will see the most polluting vehicles, like old buses, taxis, coaches and lorries, discouraged from entering the zone through charges”. To be able to do this in an effective manner in Nairobi would require better fleet characteristics' capture, that is, having information to answer: What is the breakdown of cars/LGVs, HGVs and other vehicles?, What are the average pollution emissions per distance travelled for the different vehicles? The use of remote sensing devices to measure vehicle by vehicle emissions might be advantageous to obtain this information (Ropkins et al., 2017), although this technology is likely to be prohibitively expensive for Nairobi at this point in time, it could be included in designs for the future.

In addition, there may be some environmental gains from introducing traffic calming measures to help lessen emissions associated with erratic revving, speeding and associated brake pad and tyre wear. Studies suggest that investment in such interventions can be associated with effective speed reduction, with de Borger and Proost (2013) estimating a reduction in the range of 15% to 40%. The authors also cite Wolff and Perry (2012) who indicate that, in the designated areas, low emission zones in German cities resulted in average pollution reductions of 8.7% (de Borger & Proost, 2013). However, these traffic calming measures need to be used judiciously. Glaister suggests in Hitchcock et al. (2014), that speed reduction, traffic volume management and smoothing traffic flow can improve air quality and cut CO₂ emissions, congestion and accidents. Nevertheless, interventions such as speed tables and bumps can result in stop-start associated emissions as vehicles brake and then surge away from the calming intervention.

Network performance improvements may also be adopted to enable smoother, less polluting traffic flows which facilitate access for all road user groups. Junction improvements to balance the demands of motorized and NMT traffic could be key to engendering greater equity of access to the city for pedestrians and cyclists. Another junction-related intervention could be to optimize traffic signal control to allow green waves to be enabled which effectively lessen a vehicle's likelihood of being stopped at a red light if it travels at a defined lower speed. This method avoids constant stopping and starting at traffic signals, thereby decreasing fuel burn and wear and tear on tyres and brakes which also contribute to particulate emissions.

Other potential interventions include a mixed set of options. For

example, parking controls could be introduced in the city to deter journeys being made by car and encourage a shift to alternative modes. Management of on-road parking to dissuade people from stopping randomly and blocking traffic flow is another option. The growth of information and communications technology (ICT) means that the promotion of teleworking is now a viable option which can lessen demand for travel to/from the city centre at peak times and, thus, can provide environmental benefits of potentially decreasing congestion and traffic pollution, with associated economic benefit of increasing productivity with less time wasted in traffic delays. It is equally important that public education is seen as another option, for example, about the detrimental environmental impacts of practices such as drivers mixing good diesel with kerosene (Vidal, 2016). If this were to be matched with regulation and monitoring, advances in people's understanding of the behavioural choices they make which contribute to congestion would be improved.

In the longer term, effective land use management and development planning around economic and social hubs away from the congested centre could mean shorter trips to local facilities where workplaces, shops and entertainment are co-located. This would lessen demand for intra-urban trip-making and provide opportunities for public transport to link into walking and cycling infrastructure built into such developments.

Transferability of policy may be of value to Nairobi's search for solutions to traffic congestion and pollution. Policy transfer enables knowledge obtained in one time and/or place to inform planning in another time or place (Dolowitz & Marsh, 1996). It may be helpful in illustrating what worked elsewhere but, importantly, it may highlight what did not work (Ison & Marsden, 2011). Improvements, based on best practice elsewhere, in public transport such as bus quality contracts (as in the UK), minimum vehicle standards and through ticketing, alongside dedicated infrastructure in the form of segregated lanes, bus gateways, assigned stops with shelters and priority measures can enhance the experience of bus users. In addition, complementary marketing campaigns to communicate improvements and changes, as well as personal travel planning could encourage some mode transfer from car to bus. Such approaches would need to be sustained to inspire necessary behaviour change.

The funding that Nairobi's governor is setting aside for NMT provides opportunities to fund dedicated infrastructure and associated measures to make walking and cycling more attractive options. Although cycling, at present, is not common in Nairobi ($\leq 3\%$), there are precedents for growth over time in the use of this mode as evidenced, for example, in the Netherlands. This country is commonly recognized for its cycling culture, yet "it was a conscious decision taken around 40 years ago, in response to problems such as fatalities and oil dependence of car travel, which resulted in conscious choice of cycling and walking as solutions to the burden of traffic" (Tight & Rajé, 2015). One of the methods of promoting cycle use could be to build on a bike-share scheme that is being piloted at Nairobi University (more information at <http://bikeshare.c4dlab.ac.ke>). At the same time, 50% of trips in Nairobi are currently reported to be on foot and it is assumed that these are mainly made in less than attractive conditions for pedestrians who are having to negotiate through congested streets and the lack of walking infrastructure such as pavements as well as traffic pollution and "roadside rubbish fires, diesel generators and...cooking stoves" (Vidal, 2016). Off-road, green routes through the city could improve these journeys substantially for both pedestrians and cyclists. Covered walkways, segregated on-road lanes and continuous pavements could also enhance the experience of NMT users. Bike-sharing Investment in these improvements may encourage people to walk and cycle more often and, in the longer term, could impact on pollution when people transfer from motorized modes to active travel.

Another intervention that could be introduced in the city is a road pricing scheme where a charge is levied for crossing a cordon such as in Stockholm, Milan and London. It has been stated that road user

charging is 'probably the best idea we have to reduce congestion and to enable better decisions on road investment' (Terrill & Emslie, 2016). In road user charging, automated number plate recognition is used to record vehicles that enter the congestion zone and payments made via online systems. The focus for a congestion charging scheme may be on restricting access for the most highly polluting vehicles, on all motorized vehicles or placing time restrictions on access across the day.

It is also important that businesses adopt adaptation planning strategies. It would appear that, thus far, this has been largely absent from business activities and decisions (Murphy & Harris, 2014). Measures could include routing to minimize fuel consumption by avoiding congested areas or timing trips at quieter times, replacement of ageing vehicle stock with more fuel-efficient options, consolidating loads for greater efficiency by eliminating empty trucks dead-heading back to depot (i.e. making trips unloaded).

4. The case for holistic planning

It would appear that neither infrastructure nor alternative approaches would suitably address the pollution toll on people and the environment in Nairobi. Instead, a series of measures which, over time, erode car dependency and lessen the use of highly polluting vehicles, while providing clean, sustainable alternative mobility options would seem to be a more viable and holistic solution.

The World Bank (Davido, 2014) indicates that this is an approach that has been successfully adopted in Latin America:

"In recent years, the World Bank Group has taken steps to help São Paulo develop public transport infrastructure, such as providing over \$1 billion in investment support to build new metro lines.

However, international experience suggests that while improved public transport services often provide viable alternatives to vehicles, complementary actions are needed to persuade many commuters to leave their cars at home.

In 2011, the Bank Group launched pilot "Voluntary Corporate Mobility" programs in São Paulo and Mexico City to ease traffic congestion in these two mega-cities, while also helping business and municipal organizations identify and adopt new ways of getting people to and from work.

Voluntary Corporate Mobility programs are company-led efforts to reduce the commuting footprint of employees. Common strategies include encouraging people to:

- Use mass transit and limit their use of single occupancy vehicles
- Commute during non-peak hours
- Work remotely from home
- Use non-motorized modes of transport such as bicycles

Reducing use of single-occupancy vehicles reduces pollution and carbon emissions, improves traffic flow, and creates energy savings."

There is a need for infrastructure investment to be complemented by policy, legislation and active regulation to meet the challenges of congestion and pollution. Planning would benefit from being less focused on facilitating vehicle access and travel through the city as it has been in the past. Instead, it should be people-focused and aimed at improving the social and environmental aspects of sustainability, while looking at new ways of promoting economic growth. If contemporary scenes of road space overburdened by fossil fuel burning vehicles are to be replaced by images of green space, dedicated walking, cycling and public transport facilities and improved ambiance, life in Kenya's capital will be healthier and happier. Political will, private sector commitment and public engagement are all necessary to achieve this goal for Nairobi.

Without assurance that all stakeholders could come together to agree and develop a sustainable and integrated transport sector, it is unlikely that any step change in the city's congestion and pollution

could take place. The apparent miasma of policy, strategy, maintenance, finance and planning in transport governance in Kenya, in general, was described in 2001 as follows:

- overall road policy framework is not integrated to promote a positive impact and generate cumulative positive externalities
- policy does not provide a balanced approach to strengthening and rehabilitating existing assets, on one hand, and constructing new roads and bridges, improving low-grade sections and widening roads to four lanes, on the other
- there have been unexplained reversals and weak implementation of specific policy strategies
- there has been little progress towards instituting legal and regulatory frameworks for private-sector participation
- there has been no privatisation strategy, such as for unbundling viable roads into build-operate-transfer concessions for awarding through competitive bidding
- in terms of quantity, increased decentralization, cess [tax or levy] on agricultural products, rural access, and minor roads programmes have served the road stock well in spite of the glaring lags in maintenance, repair and rehabilitation, and disjointed institutions
- the post-1995 period has witnessed ambitious strategic road planning and policy reforms, including the formation of the KRB, the introduction of a road maintenance levy fund and axle-load limits, and the plan for increased private-sector participation in all facets of road service delivery (Wilson & Wasike, 2001)

However, there appears to have been progress made in developing a national integrated transport strategy over the past 15 years to guide how transport infrastructure is used, managed and governed (Opiyo & Mitullah, 2016). The focus at national level on infrastructure provision is to be credited but Opiyo and Mitullah suggest that the national level focus needs to be matched by local policies at county level which enhance mobility and connectivity within counties and to other areas.

In addition, the issue of corruption in Kenya needs to be considered in the context of achieving successful implementation of practical solutions to traffic pollution. The country is ranked at 26/100 on the Corruptions Perceptions Index (2016) – the score indicates the perceived level of public sector corruption on a scale of 0 (highly corrupt) to 100 (very clean) (Transparency International, 2018). Misappropriation of funds has been described as one of the major challenges to the successful implementation of Kenya's Vision 2030 (Bolo & Nkirete, 2012). This has implications for the attainment of the step change that is required in transport strategy, policy and infrastructure implementation which aims to lessen the impacts of traffic pollution.

5. Future research

With burgeoning challenges posed by congestion in East African cities, it is important that ideas around congestion reduction are explored further to determine their potential and viability for these cities. An understanding of the contemporary social, environmental and economic impacts of congestion in the cities would help governments, planners, investment institutions and other stakeholders to tailor solutions to mitigate current difficulties and future-proof against a worsening of conditions without intervention.

Wide-ranging policies which could positively impact on congestion need further examination at the local level. For example, road user charging schemes may be successful in Europe but it is not clear whether they could be as effective in East Africa. Studies exploring the feasibility of congestion charging, its social and economic impacts and derived pollution benefits are all needed.

At a finer scale, an exploration of people's lived experience of cities such as Nairobi, looking, for example, at daily trips, personal responsibilities and household activities can lead to insights to help develop more effective solutions that meet real needs in the urban community.

The potential of non-motorized transport, and walking and cycling, in particular, to meet travel needs in the city needs to be better understood. This would involve research with different social groups to gain nuanced understandings of attitudes to these modes and ways in which they may be made more attractive mode choices. Any intervention should be mindful to be equitable towards all sections of society regardless of gender, age, disability, profession, etc.

Alternative interventions such as bike-share, e-bike share, ride-share and personal travel planning would also benefit from further exploration in Nairobi. All have potential to be a part of a wider set of policies and strategies for lowering fossil fuel dependence in the transport sector but current knowledge of their potential viability and desirability in the city is largely unexplored.

6. Conclusion

Congestion and traffic-related pollution characterize cities experiencing rapid urban growth. In East Africa, there is acknowledgement of the detrimental effect of congestion on cities and an awareness that this affects productivity, competitiveness and sustainability. However, steps made in the region to effectively ameliorate the problems of congestion appear to be in their infancy.

Nevertheless, Kenya seems to have made some progress in its pursuit of its Metro 2030 strategy, planning a bus rapid transit system and placing the most stringent limits in East Africa on age of vehicle imports. The policy of dedicating a fifth of the road budget in Nairobi to non-motorized transport is another indicator of commitment to sustainability. However, this policy pledge needs to be matched in practice by multi-faceted efforts to recalibrate the balance of traffic on the city's roads via infrastructure, behavioural and alternative interventions to increase active modes and public transport.

As Nairobi searches for more sustainable approaches to mobility, it may be useful to suggest a feasible timeline for change. Initially, it is likely that it is through small wins that the process of change may be most effective in gaining the buy-in of local people. Therefore, the adoption of bike-share and cycling training programmes, introduction of off-road walking routes and use of paint on roadways to reassign space for pedestrian use (see, for example, the work of Janette Sadik-Khan in New York) could form initial steps in changing people's thinking about their streets and city. Dedicated days for promoting more sustainable modes (such as *Cicloviá* in Bogotá and *Hoy No Circula* in Mexico City) could also help illustrate what the city would look like without motorized traffic. In parallel with such activities and interventions, infrastructure development and change could be on-going. By drawing up regulations for less congested fleets of public transport vehicles, the purchase of minimally polluting new buses could happen over time, with a deadline of, say, 3 to 5 years ahead for all vehicles to meet the regulatory criteria. In terms of junction improvements and optimizing traffic signal control, work could begin early on in the process with an audit of needs and specification of additional equipment to enable the transition to smoother traffic flows. Parking policy changes could also begin in the short term to allow regulatory instruments to begin to pass through the necessary legislative processes. The building of new infrastructure could prove to take the longest time to implementation. The design and finance aspects would need to be prioritized and given tight deadlines to facilitate the start of building and implementation.

In order to make transport change happen, a designated organization for sustainable transport with delegated authority to allow timeous decision-making may be required. Such an organization would need to be unshackled by professional silos and politics and built on a common purpose of creating a thriving capital city with good air quality, effective accessibility and excellent quality of life.

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